

WE CLAIM:

1. An apparatus for measuring the displacement of, and force on, visco-elastoplastic media below a surface thereof, the apparatus comprising:
  - an upper plate having a top surface and mounted in the apparatus such that a displacement force exerted on the top surface will move the upper plate a displacement distance downward toward a base;
  - guides operative to maintain the upper plate and the base in alignment such that movement of the upper plate toward the base is along a displacement axis;
  - a calibrated bias element operative to exert a calibrated bias force resisting movement of the upper plate toward the base;
  - a displacement measuring device operative to measure the displacement distance moved by the upper plate towards the base, and operative to generate a movement signal corresponding to the displacement distance; and
  - a data acquisition system operative to receive and record the movement signal, and operative to calculate the displacement force exerted on the top surface of the upper plate required to move the upper plate the displacement distance against the calibrated bias force.
2. The apparatus of Claim 1 wherein the displacement measuring device comprises a Hall effect displacement measuring assembly.

3. The apparatus of Claim 2 wherein the Hall effect displacement measuring assembly comprises a magnet fixed to one of the upper plate and the base, and a Hall effect transducer fixed to the other of the upper plate and the base.

4. The apparatus of Claim 3 wherein the data acquisition system is further operative to record the displacement distance as the displacement distance changes over a time period.

5. The apparatus of Claim 4 wherein the data acquisition system is further operative to calculate the displacement force as the displacement force changes over the time period.

6. The apparatus of Claim 1 wherein the calibrated bias element comprises a spring having a known spring constant such that the displacement force required to move the upper plate through the displacement distance toward the base can be calculated.

7. The apparatus of Claim 1 further comprising a displacement limiting assembly operative to limit the displacement distance.

8. The apparatus of Claim 1 further comprising an accelerometer attached to the base, and operative to measure movement along the displacement axis of the base with respect to the visco-elastoplastic media.

9. The apparatus of Claim 1 wherein the guides comprise an upper casing member telescoping with respect to a lower casing member, and wherein the upper plate is fixed to the upper casing member and the base comprises the lower case member.

10. The apparatus of Claim 1 wherein the visco-elastoplastic media is soil.

11. A method of measuring the displacement of, and force on, visco-elastoplastic media below a surface thereof, the method comprising:

providing an upper plate having a top surface, and a base located at a desired depth under the surface of the visco-elastoplastic media;

orienting the upper plate relative to the base such that a displacement force exerted on the top surface will move the upper plate a displacement distance downward toward the base;

with guides, maintaining the upper plate and the base in alignment such that movement of the upper plate toward the base is along a displacement axis;

providing a calibrated bias element operative to exert a calibrated bias force

resisting movement of the upper plate toward the base;

exerting a load force on the visco-elastoplastic media and measuring the displacement distance moved by the upper plate towards the base in response to the load force; and

recording the displacement distance, and calculating the displacement force exerted on the top surface of the upper plate required to move the upper plate the displacement distance against the calibrated bias force.

12. The method of Claim 11 wherein the displacement distance is measured with a Hall effect displacement measuring assembly comprising a magnet fixed to one of the upper plate and the base, and a Hall effect transducer fixed to the other of the upper plate and the base.

13. The method of Claim 12 further comprising recording the displacement distance as the displacement distance changes over a time period.

14. The method of Claim 13 further comprising calculating the displacement force as the displacement force changes over the time period.

15. The method of Claim 11 wherein the calibrated bias element comprises a spring having a known spring constant such that the displacement force required to move the upper plate through the displacement distance toward the base can be calculated.
16. The method of Claim 11 further comprising limiting the displacement distance.
17. The method of Claim 11 further comprising measuring movement of the base along the displacement axis with respect to the visco-elastoplastic media with an accelerometer attached to the base.
18. The method of Claim 11 wherein the guides comprise an upper casing member telescoping with respect to a lower casing member, and wherein the upper plate is fixed to the upper casing member and the base comprises the lower case member.
19. The method of Claim 11 wherein the visco-elastoplastic media is soil.